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Analysing the status, obstacles and recommendations for WCOs of restaurants as biodiesel feedstocks in China from supply chain' perspectives

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ABSTRACT

The raw material supply bottleneck is one of the obstacles currently facing the development of China's biodiesel industry. The main objective of this paper is to analyse the demands, possibilities, difficulties and suggestions surrounding the participation of restaurant enterprises in the biodiesel supply chain. Based on an analysis of the overall situation of China's biodiesel supply chain, the authors designed a structured questionnaire to survey 246 restaurant enterprises in Nanjing. The questionnaire mainly included basic aspects of restaurant enterprises, disposal of waste cooking oil (WCO), awareness and attitudes towards WCO recycling, understanding and opinion of biodiesel, and willingness and requirements for participating in the production of biodiesel. Factor analysis was then conducted on the motives of industrial restaurant enterprises for disposing of or recycling their WCO, and cluster analysis was used to classify the 246 restaurant enterprises into three clusters. Finally, the authors suggested ways to promote the development of Nanjing's biodiesel supply chain. The significant findings obtained in this paper will help to encourage restaurant enterprises to become suppliers of biodiesel production and promote the healthy development of the biodiesel industry in China.

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1. Introduction

1.1. Biofuel production and supply chain problems in China

By emitting six billion tons of CO_2 in 2007 (21% of global emissions), China overtook the US as the world's largest emitter of energy-related CO_2 (IEA, 2009). Ensuring energy security and reducing carbon emissions have become important strategic tasks for China (Wang et al., 2007; Yan and Crookes, 2009a; Zhou and Thomson, 2009). The vigorous development of the biofuels industry (bio-ethanol and bio-diesel) has become an integral part of the development of renewable energy in China and a feasible option for the replacement of fossil fuels (Peters and Thielmann, 2008; Zhang et al., 2011). Therefore, China has established development objectives for the biofuels industry to promote the widespread use of biofuels. In the Mid- and Long-term Development Strategies for Renewable Energy, the Chinese government plans to increase the current annual fuel ethanol production capacity of 1–3 million tons in 2010 to 10 million tons by 2020 and to establish a biodiesel production capacity of 0.2 million tons by 2010 and 2 million tons by 2020 (Yan and Crookes, 2009b).

Since 2005, China has become the third largest bioethanol producer in the world behind Brazil and the US, which together account for 92% of the world's ethanol production (Zhou and Thomson, 2009). China's bioethanol production capacity reached 1.83 million tons/year in 2007, and its actual yield reached 1.5 million tons/year (P. Zhang et al., 2009). By 2008, the fuel ethanol production capacity had reached 1.94 million tons (650 million gallons) (Li and Catherine, 2009).

Biodiesel is recommended for use as a substitute for petroleum-based diesel, mainly because biodiesel is not only a renewable, domestic resource with an environmentally friendly emission profile, but it is also readily biodegradable (Bozbas, 2008). Biodiesel production is not a new idea; the concept of using vegetable oil as fuel dates back to 1895 (Murugesan et al., 2009). In China, research on diesel produced from vegetable oil started in 1981, and several biodiesel production technologies have been successfully developed using the feedstock of rap oil, *Cormus wilsoniana* fruit oil, *Jatropha curcas* oil, soybean oil, rice bran oil residue, and restaurant waste oil (P. Zhang et al., 2009). As of September of 2008, there were hundreds of biodiesel enterprises in China, about 60 of which were in the over ten thousand ton class. China's production capacity exceeds 3.0 million tons/year, with waste oil, vegetable oil residue, and restaurant waste oil as feedstock, and the conversion rate is over 75% (P. Zhang et al., 2009). Chinese biodiesel production is minimal compared to its ethanol production (Zhou and Thomson,

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2009); the actual yield of biodiesel was only 0.3 million tons in 2007. However, biodiesel is an important part of China's developing biofuel strategy. Although it is still in its infancy with small capacity, it is expected to begin to develop more rapidly in coming years (Wen, 2006). Compared with bioethanol, the process of Chinese biodiesel industrialization has been relatively slower as biodiesel is not sold to the public in the retail network of oil. However, the productivity and expected development scale of China biodiesel are very large.

Researchers have shown that the bottlenecks of the development of the biofuels industry are not technical problems but non-technical problems in the EU (Kes and Tomas, 2007; Kirsti and Jon, 2008), such as supply chain problems. Development of a robust and sustainable biofuels industry will require a large and complex supply chain, which will improve biomass feedstock supply reliability, reduce product costs, and enable coordination of the relationships of the various members of the supply chain, including biomass suppliers, biofuel producers, retailers, logistics providers, government and end consumers (Kirsti and Jon, 2008). Moreover, some special supply chain management core problems have been addressed in prior research: industry organization (Altman and Johnson, 2008, 2009; Rösch and Kaltschmitt, 1999), contract mechanism (Altman et al., 2007; van Loo and Koppejan, 2003), biomass purchase strategy (Overend, 1993) and coordination policies (Y. Zhang et al., 2009a,b; Pan et al., 2010).

The Chinese biofuels industry faces some difficulties similar to those encountered by the EU. One of the core bottlenecks involves raw materials, including the unreliability of supplies (P. Zhang et al., 2009; Pan et al., 2010). According to scholars, the key solution to this problem is to enhance the coordination of the biofuel supply chain and reduce the cost of raw material supply (Y. Zhang et al., 2009a,b).

The principal obstacle to developing the biodiesel industry in China is the lack of eligible organic sources. At present, almost all production is based on animal fat or waste vegetable oils, which result in a poor-quality product (Zhou and Thomson, 2009). The key determinant of the biodiesel industry's development will be the availability of feedstock (Wu et al., 2010). Thus, as suggested by some experts, cultivating suitable woody, oily trees in mountainous areas, marginal lands or dry desert areas seems to be the best solution for mass plantation of energy crops in China (Wen, 2006). *Jatropha* one of the non-edible tree-based oil seeds available in China, which is mainly distributed in the Sichuan, Guizhou, and Yunnan Provinces, has recently received attention in this respect (Wu et al., 2010).

Along with biomass conversion technology, policies and incentive mechanisms to effectively reduce biofuels' production costs in China, one of the most important steps is to reduce biomass feedstock supply costs related to the supply of feedstock resources, supplier cooperation, raw material prices, supply reliability and logistics costs. In essence, the supply chain problem of the biofuels industry is critical in China.

1.2. Literature review: use of waste cooking oil for biodiesel production

The idea of reusing waste cooking oil (WCO) seems attractive based on bioresource sustainability, environmental protection and economic considerations (Tsai et al., 2007; Gui et al., 2008). Upham et al. (2009) reviewed the sustainability performance of five potential UK biodiesel feedstocks and concluded that only used cooking oil has guaranteed sustainability benefits. Pleanjai et al. (2009) compared the life cycle greenhouse gas (GHG) emissions from used cooking oil methyl ester (UCOME) and conventional diesel used in transport in Thailand. They found that the GHG emissions from the life cycle of UCOME are 93% less than those of conventional diesel production and use.

At present, the high cost of biodiesel is the major obstacle to its commercialization (Ma and Hanna, 1999; Zhang et al., 2003a; Demirbas, 2007; Peng et al., 2008). The raw materials cost constitutes the majority of biodiesel's production costs (van Kasteren and Nisworo, 2007). It has been reported that approximately 70–95% of the total biodiesel production cost arises from the cost of raw material (Zhang et al., 2003b). Meng et al. (2008) also indicated that approximately 70–85% of the total biodiesel production cost arises from the cost of raw material. Furthermore, Phan and Phan (2008) thought that the high cost of vegetable oils could account for up to 75% of the total manufacturing cost of biodiesel. Thus, minimizing the raw material cost is one of the critical steps for reducing the high cost of biodiesel (Zhang et al., 2003a,b). The use of WCO instead of virgin oil to produce biodiesel is an effective way to reduce the raw material cost because WCO (WCO) is 2–3 times cheaper than virgin vegetable oil.

Moreover, production of biodiesel from WCO will avoid competition for the same oil resources for use as food and fuel as well as overcome the WEO disposal problem (Gui et al., 2008). From the waste-to-energy viewpoint, WCO is amongst the most attractive and easily obtainable recycled feedstocks apart from agricultural residues (Singhabhandhu and Tezuka, 2010). Therefore, WEO should be used as the primary feedstock for biodiesel production throughout the world (Gui et al., 2008).

Nevertheless, more than 95% of the world's biodiesel is currently produced from edible oil (Gui et al., 2008). Using non-edible oil or waste edible oil is important for developing a sustainable biodiesel industry. The quantity of WCO in various countries or regions has been investigated. Gui et al. (2008) have indicated that a total of more than 15 million tons of WCO are generated annually by the US (10.0 million tons/year), China (4.5 million tons/year), the EU (0.5–1.0 million tons/year), Taiwan (0.07 million tons/year), Japan (0.45–0.57 million tons/year), Canada (0.12 million tons/year) and Malaysia (0.5 million tons/year).

According to the above analysis, the majority of biodiesel could be derived from used cooking oil. It is feasible for Chinese biodiesel production to use WCO for three reasons.

First, in China, the potential amount of available WCO would guarantee the smooth operation of all current biodiesel production lines. China consumes approximately 22 million tons of refined edible oils annually (Peng et al., 2008; Meng et al., 2008). Table 1 shows the quantity of edible oils consumed in recent years (Wu, 2010). Although quantity estimations of the WCO generated annually in China vary from more than 4.5 million tons (Meng et al., 2008) to about 1.0–2.5 million tons (Peng et al., 2008), either value is enough for the Chinese biodiesel industry to obtain raw materials at a lower price. With China's social and economic development, restaurants have expanded, and thus the output of WCO will increase.

Second, with China's continuous emphasis on the renewal and recycling of resources, a number of relating regulations and policies have been introduced. In this context, those that endow the recycling of WCO with legal protection and an operating environment are most important. In recent years, some important regulations and laws related to WCO recycling and disposal were enacted in China, such as "Food Health Law" (1995), "The Regulation of Waste Edible Oils Management by Food Production Enterprises" (2002), "The Message about Organisation of Disposal and Reusing of Kitchen Wastes" (2010), and "Some Notations about Improving Management of WCOs and Kitchen Waste from the office of the Chinese State Department" (2010). Moreover, various local governments have enacted regulations and laws related to WCO management, including Shenzhen, Shanghai, Tianjing, and Fujian. In Nanjing, a similar regulation was made effective in 2006 (the regulation for Nanjing city about WCOs management, ACT 198 of the Nanjing government). Furthermore, "The Regulation of Kitchen Waste Management of Jiangsu" will be enacted in the near future.

Table 1
Total consumption data of five types of edible oils between 2004 and 2009 (10^3 tons).

Year[a]	Bean oil	Palm oil	Rap oil	Peanut oil	Total consumption
2008–2009	9283	6050	4410	2860	22,603
2007–2008	8802	5051	4407	2761	21,021
2006–2007	8333	5150	4369	2420	20,272
2005–2006	7800	4862	4521	2095	19,278
2004–2005	7600	4515	4586	2040	18,741
2003–2004	6944	3564	4480	2021	17,009

[a] The statistics year refers to the phase from June to May of next year.

Third, the booming biodiesel industry demands the extension and expansion of the production chain, reflecting the advantages of WCO's use as a raw material. There are some significant practices and many good experiences from some developed countries or regions, such as Japan, the EU, Taiwan and the US.

Currently, WCO still accounts for a low proportion of the raw materials used in the production of China's biodiesel. The proportion is about 10–15%. To achieve large-scale production, the reliability of the supply of WCO must be guaranteed. At present, some Chinese cities, such as Shanghai, have started to use WCO for the large-scale production of biodiesel, but some new problems require further attention. From the supply chain perspective, using WCO for the large-scale production of biodiesel will require efficient coordination of the relationship between raw material suppliers and biodiesel manufacturers.

However, it is lack to study the biodiesel supply chain with the using of WCO in the past decades. And the majority of relating with biodiesels focused on the converting technologies (Bautista et al., 2009; Enweremadu and Mbarawa, 2009; Wu et al., 2010; Xu et al., 2009), social-economic (Zhang et al., 2011), environmental impacts (Demirbas, 2009; Lechón et al., 2009; Smeets et al., 2009; Yang et al., 2009; Upham et al., 2009; Talens Peiró et al., 2010), promoting polices (Wiesenthal, 2009; Steenberghen and López, 2008), logistics operations (Elmore et al., 2008; Ayla et al., 2008; Rogers and Brammer, 2009; Cundiff and Grisso, 2008), product performances test (Jansson et al., 2009; Shao and Chu, 2008). In China, only a few researches (Y. Zhang et al., 2009a,b; Pan et al., 2010) have carried out the study related to the bioenergy supply chain.

1.3. Research objectives and scope

This paper selects restaurant enterprises as the subjects due to the following two reasons (Canakci, 2007). First, the amount of WCO produced by restaurant enterprises is bigger than that of ordinary families; second, restaurant enterprises recycle and dispose WCO in a more market method, and it is more suitable to use supply chain theories to coordinate and manage restaurant enterprises. The objective of this paper is to promote restaurant enterprises to participate in the biodiesel supply chain through the survey of the generation, recycling, disposal and attitudes towards WCO and the understanding of biodiesel and cooperation willingness, etc.

From the perspective of supply chain, this paper discusses the difficulties encountered by restaurant enterprises' participating in the biodiesel supply chain and offers relevant suggestions. In the premise of determining the necessity and feasibility of using the WCO from restaurant enterprises as the raw material of biodiesel, the objective of this paper is to survey and reveal the chances, factors and difficulties preventing restaurant enterprises from participating in biodiesel supply chain, and then offer countermeasures and suggestions promoting restaurant enterprises to participate in biodiesel supply chain on the basis of the survey results.

2. Materials and methods

2.1. Data collection

In April and May of 2009, the authors randomly carried out data collection at restaurant enterprises in Nanjing. Given the needs of the study, the structured questionnaire method was adopted. Over 300 restaurant enterprises were surveyed, and the questionnaires were completed by persons in charge of restaurant enterprises with the coordination of the survey team. The individuals surveyed were responsible for disposing of WCO on behalf of their respective restaurant enterprises and provided their attitudes and opinions about their respective restaurant enterprises' disposal of WCO. A total of 246 valid questionnaires were obtained.

The surveyed restaurant enterprises were distributed in all districts and counties of Nanjing. Table 2 shows the basic information on the 246 restaurant enterprises and the respondents. It can be seen from Table 2 that persons in charge of restaurant enterprises have low levels of education in general; 41.9% had only a junior secondary education, and most (76.8%) were over the age of 30. The scale and structure of the surveyed restaurant enterprises are basically consistent with the current characteristics of Nanjing and China's other major cities. The surveyed restaurant enterprises are mainly small and medium-sized restaurant enterprises. For

Table 2
The basic information of the respondents and the surveyed restaurants.

Items	Value	Frequency
Age of the respondents	≤20	2.0%
	21–30	21.2%
	31–40	46.3%
	>41	30.5%
Education level of the respondents	Did not complete high school	41.9%
	High school graduate	58.1%
	Bachelors	0.0%
	Graduate	0.0%
Registered capital (ten thousands RMB)	≤10	16%
	11–50	54%
	51–100	26%
	>100	4%
Seat number	<50	27.6%
	51–100	54.5%
	101–200	13.8%
	201–500	2.8%
	>500	1.3%
Average daily turnover	≤2000	36.2%
	2001–5000	35.4%
	5001–100,000	15.9%
	100,001–500,000	11.8%
	>500,000	0.7%
Number of dinners per day	≤100	37.4%
	101–200	44.7%
	201–400	11.4%
	401–500	3.7%
	>500	2.8%

example, 30% of the restaurant enterprises had more than RMB500,000 in registered capital, 17.9% had no more than 100 seats, 12.5% had average daily turnover over RMB100,000, 15.1% served more than 200 dinners per day.

2.2. Questionnaire design

The questionnaire design adopted in this paper is based on these existing literature (Y. Zhang et al., 2009a,b), mainly reflecting the current situations of the generation and disposal of WCO from the surveyed restaurant enterprises, the recycling attitudes and motives of the surveyed restaurant enterprises, and the possibilities, demands and existing restraints on the surveyed restaurant enterprises in participating in biodiesel supply chain. The questionnaire was given in Appendix A. The questionnaire is consisted of four main parts as follows:

- The first part of the questionnaire describes the basic information of the respondents such as age and education level.
- The second part of the questionnaire is related to the basic information of the surveyed restaurants including of registered capital, seat number, average daily turnover, number of dinners per day, quantity of edible oils consumed per day and quantity of WCO recycling per day.
- The third part of the questionnaire is mainly about the current situations of the generation, management and disposal of the WCO, including disposal methods, disposal frequency, disposal satisfaction, sale price, managerial staff, and configuration of facilities.
- The fourth part of the questionnaire is mainly to understand the attitudes and motives of the surveyed restaurant enterprises in recycling and disposing WCO, including the understanding of the surveyed restaurant enterprises on the significance of WCO and understanding of unreasonable disposal methods and the motives of recycling WCO. Furthermore, the part of the questionnaire also reflects the understanding, cooperation willingness and cooperation demands of the surveyed restaurant enterprises on biodiesel supply chain. The 5-point Likert scale was adopted to construct semantic evaluations, such as greatly agree, agree, medium, disagree, and greatly disagree. Similarly, the 5-point Likert scale was adopted to construct semantic evaluations, such as “very important, important, medium, unimportant, and very unimportant” and “very necessary, necessary, medium, unnecessary and very unnecessary”.

2.3. Analysis methods

This paper adopts SPSS 17 statistical software for analysis in strict accordance with statistical theory (Li and Luo, 2005). At first, the paper adopts descriptive statistical method to analyse the mean value, variance and frequency. Then, the principal component analysis method is adopted to carry out factor analysis on the understanding, motives and cooperation demands of restaurant enterprises on WCO recycling. At last, the clustering method is utilized to conduct detailed study of the surveyed restaurant enterprises.

3. Results

3.1. Generation of WCOs

Amongst the surveyed restaurant enterprises, the average daily consumption of cooking oil was 39.98 kg (variance = 28.939). The average daily consumption of cooking oil per seat was 0.423 kg, the average consumption of cooking oil per dinner was 0.222 kg, and the consumption of cooking oil per unit turnover was 3.97 kg/RMB1000. Fig. 1 describes the quantity of edible oils consumed per day by the surveyed restaurant enterprises. It is showed that 74.4% of the surveyed restaurant enterprises used less than 40 kg of cooking oil of various types per day.

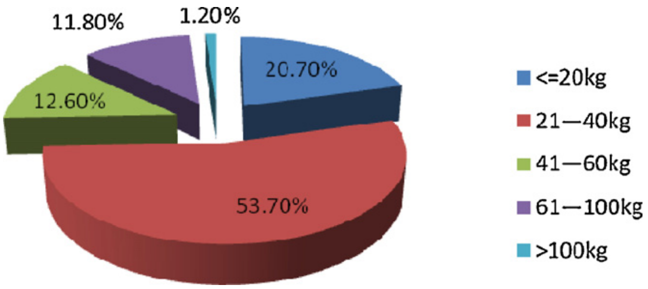


Fig. 1. Quantity of edible oils consumed per day (kg).

According to our survey, the rate of generation of WCO is about 50%, based on which we can estimate that the generated amount of WCO in restaurant enterprises in Nanjing is about 1.985 kg/RMB1000 per unit turnover in 2009.

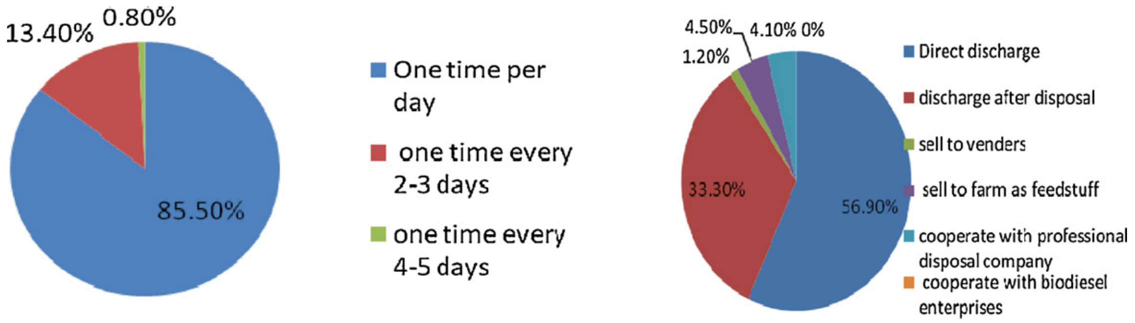
3.2. Recycling facilities and management staff for WCO disposal

As an important part of reverse logistics (Fleischmann et al., 2000; Zhang, 2006), recycling facilities and organizations will also impose direct impacts on WCO recycling. Some Chinese national and local laws and regulations, such as ACT 198 of the Nanjing government (Nanjing Government, 2006), have clearly stipulated that restaurant enterprises must build a device for recycling and disposing of WCO to prevent the wasting of resources and environmental pollution. However, 91.06% of the surveyed restaurant enterprises did not have any such special recycling or disposal device, 33.74% were considering building the recycling or disposal device, and only 8.94% had recycling and disposal devices meeting the national standards. Likewise, only 2.44% of the surveyed restaurant enterprises assigned some special staff to perform daily WCO management, including collection, disposal, and record keeping. Of the remaining restaurants, 27.64% were planning to create such a post, and the rest had no such intention.

3.3. Disposal status

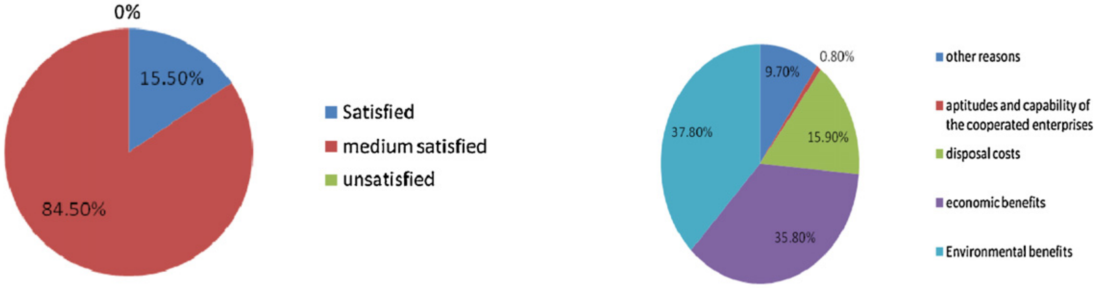
Fig. 2 shows the WCO dispose status of the surveyed restaurant enterprises. We can find some results:

- Disposal frequency. Of the surveyed restaurant enterprises, 211 (85.8%) disposed of WCO once per day; 33 (13.4%) every 2–3 days; and 2 (0.8%) every 4–5 days.
- Disposal ways. In this survey, we find that the recycling rate of WCO is very low. The average daily recycling quantity of WCO is about 3.5 kg per surveyed restaurant according to our survey. It is found that the majority of WCO generated in Nanjing is wasted. Amongst the six disposal methods, 90.2% of the surveyed restaurant enterprises chose discharge, and only 9.8% chose recycling WCO. At the time of the survey, none of the surveyed restaurant enterprises had chosen to cooperate with biodiesel enterprises.
- Satisfaction level. It is showed that only 15.5% of the surveyed restaurant enterprises were satisfied with their current disposal methods.
- Selection factors for disposal ways. Three most important factors of selection n disposal ways are environment benefits (37.8%), economic benefits (35.8%) and disposal cost (15.9%).



A. disposal frequency

B. disposal ways



C. satisfaction level

D. selection factors for disposal ways

Fig. 2. The WCO disposal status of the surveyed restaurants.

3.4. Awareness of the significance of WCO recycling

The reliability level of the nine recycling factors was $\alpha = 0.797$. Fig. 3 shows the surveyed individuals' understanding of WCO recycling significance, According to Fig. 3, the two factors with the most significance are "WCO recycling can effectively improve the health conditions of enterprises" (mean value = 3.39); "WCO is usually wasted" (mean value = 3.36). The statement about recycling that was least endorsed was, "WCO recycling is the social responsibility of enterprises" (mean value = 3.2).

Table 3 gives the factor analysis results. Based on Table 3, the principal components analysis method was adopted to conduct factor analysis on the nine recycling significances, the result of which classifies them into three principal components: factor 1, a responsibility and capability factor; factor 2, an economic and environment factor; and factor 3, a resource-saving factor. These three factors explain 65.1% of the initial variance (KMO = 0.828, Bartlett sphericity test sig. = 0.00).

3.5. Motives for WCO recycling

The reliability level of the recycling motivational factors was $\alpha = 0.682$. Fig. 4 shows the surveyed restaurant respondents' response on motives for WCO recycling. The surveyed restaurant enterprises reported that the most important motivational factors for WCO recycling were "to save the cost" (mean value = 3.72) According to the surveyed restaurant enterprises, the least important factors were "private acts of employees" (mean value = 2.09).

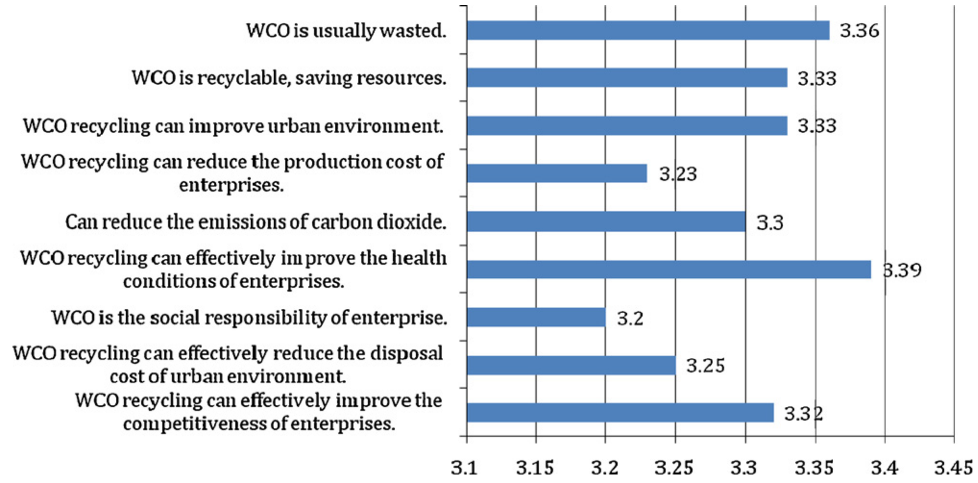


Fig. 3. The surveyed restaurant respondents' response on the significance of WCO recycling.

Table 3
Awareness about the recycling significances of WCO and factor analysis.

Components	Loadings[a]	%Variance explained	Cronbach's α
Component 1[b] (responsibility and capability factor)		28.3	0.811
WCO recycling can effectively improve the competitiveness of enterprises.	+0.801		
WCO recycling can effectively reduce the disposal cost of urban environment.	+0.824		
WCO is the social responsibility of enterprise.	+0.781		
WCO recycling can effectively improve the health conditions of enterprises.	0.650		
Component 2[b] (economic and environmental factor)		22.3	0.675
Can reduce the emissions of carbon dioxide.	+0.706		
WCO recycling can reduce the production cost of enterprises.	+0.789		
WCO recycling can improve urban environment.	+0.665		
Component 3[b] (resource-saving factor)		14.5	0.691
WCO is recyclable, saving resources.	+0.868		
WCO is usually wasted.	+0.689		

[a] After varimax rotation.
[b] Variables with loadings less than 0.5 were omitted.

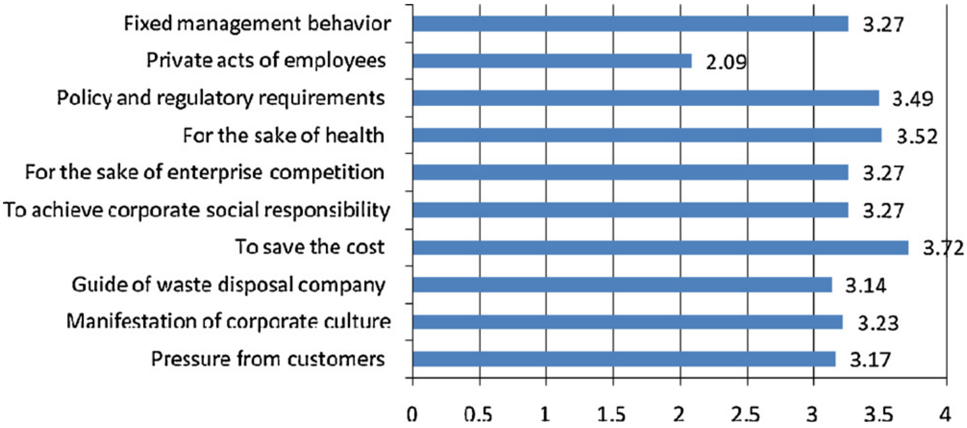


Fig. 4. The surveyed restaurant respondents' response on motives for WCO recycling.

The principal components analysis method was adopted to carry out factor analysis on the ten recycling motivational factors. Based on the results listed in Table 4, four principal components can be distinguished: factor 1, pressure from culture and supply chain; factor 2, responsibility and competition; factor 3, policy and health; and factor 4, behavioural atmosphere. These four principal factors account for 66.5% of the initial total variance (KMO = 0.732, Bartlett sphericity test sig. = 0.00).

3.6. Understanding biodiesel production and products

Most respondents (99.2%) were unknown about the operations of biofuel supply chain, and only 0.8% of the respondents had some knowledge about the operations of biofuel supply chain. In terms of the understanding about using WCO to produce biodiesel, 4.1% of the respondents thought that WCO could be used to produce biodiesel; 20.8% firmly declared that WCO could not be used to

Table 4
Motives for WCO recycling and factor analysis.

Components	Loadings[a]	%Variance explained	Cronbach's α
Component 1[b] (pressure from culture and supply chain)		25.3	0.876
Pressure from customers	+0.878		
Manifestation of corporate culture	+0.921		
Guide of waste disposal company	+0.841		
Component 2[b] (responsibility and competition)		17.6	0.742
To save the cost	+0.505		
To achieve corporate social responsibility	+0.792		
For the sake of enterprise competition	+0.739		
Component 3[b] (policies and health)		12.2	0.655
For the sake of health	+0.832		
Policy and regulatory requirements	+0.674		
Component 4[b] (behavioural atmosphere)		11.4	0.625
Private acts of employees	+0.801		
Fixed management behaviour	+0.550		

[a] After varimax rotation.
[b] Variables with loadings less than 0.5 were omitted.

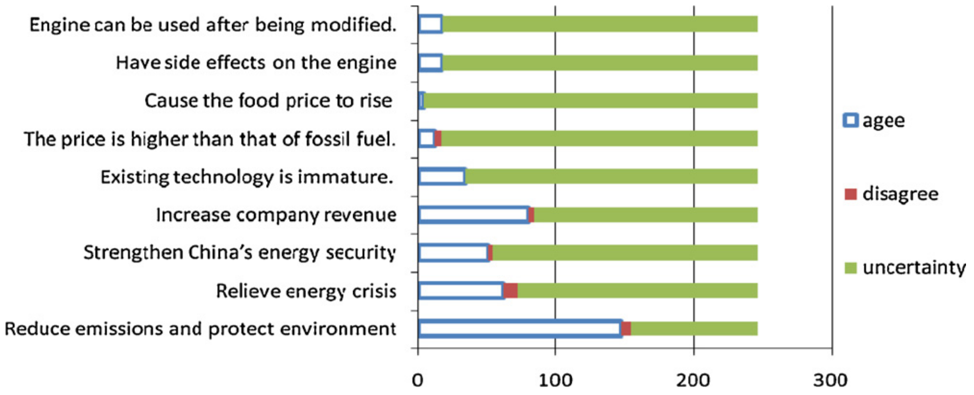


Fig. 5. The understanding degree of respondents about the applications of biodiesel.

produce biodiesel; and 75.1% were unsure about whether WCO could be used to produce biodiesel. Fig. 5 shows the distribution of respondents' knowledge about the applications of biodiesel. The reliability level of respondents' knowledge was $\alpha = 0.682$.

3.7. *Willingness to cooperate with biodiesel manufacturers*

A total of 24.4% of the restaurant enterprises were willing to cooperate with biodiesel manufacturers, 71.5% were willing to cooperate with biodiesel manufacturers in a general sense, and 4.1% clearly declared that they were unwilling to cooperate with biodiesel manufacturers.

3.8. *Expected sale price of WCOs*

Regarding the sale price of the WCO during the cooperation period, 64.6% of the surveyed restaurant enterprises thought that 500 yuan per ton was an acceptable sale price, 29.7% required that the price be in the range of 500–800 yuan per ton, and 5.7% thought that a price of 800–1000 yuan per ton would be appropriate.

3.9. *Cooperation demands*

The total reliability level of the cooperation demand factors was $\alpha = 0.846$. Fig. 6 shows the statistics regarding the expected cooperation demands on biodiesel manufacturers when the restaurant enterprises participate in the biodiesel supply chain. According to the surveyed restaurant enterprises, the two most important cooperation demand factors are "reasonable collection price" (mean value = 3.70) and "fixed door-to-door collection service" (mean value = 3.70). According to the surveyed restaurant enterprises, the two least important factors are "provide WCO disposal personnel with trainings" (mean value = 3.10) and "need professional disposal personnel" (mean value = 3.10).

The principal components analysis method was adopted to carry out factor analysis on the ten cooperation demand factors. Based on the analysis of Table 5, two principal components were obtained: factor 1, network and value-added services; and factor 2, organizational services. These two factors account for 70% of the initial variance (KMO = 0.774, Bartlett sphericity test sig. = 0.00).

3.10. *Segmenting the restaurants based on recycling motives*

For a better understanding of the differences in the understandings, motives and supply chains of the recycling cooking oil from the surveyed restaurant enterprises, this paper uses the motivational factors about WCO recycling discussed above to carry out a segmentation study on the surveyed restaurant enterprises (see Table 6 for details).

With the rapid clustering method, the surveyed restaurant enterprises were classified into the following four categories. Comparisons of the recycling of the WCO are also discussed:

- Cluster 1 includes 17.5% of the total survey sample. They agree that the most important motivational factor for WCO recycling is "pressure from culture and supply chain", and they also think "responsibility and competition" and "policies and health" are important. However, they do not agree on the importance of "behavioural atmosphere" in recycling.
- Cluster 2 includes 8.5% of the total survey sample. They agree on the importance of "behavioural atmosphere" in WCO recycling and think that "policies and health" also play an important role. However, they do not agree on the importance of "responsibilities and competition" or "culture and supply chain" in recycling.
- Cluster 3 includes 4.1% of the total survey sample. They agree on the importance of "culture and supply chain" in WCO recycling and agree that "behavioural atmosphere" can play an active role. However, they do not accept the importance of "responsibilities and competition" or "policies and health" in WCO recycling.

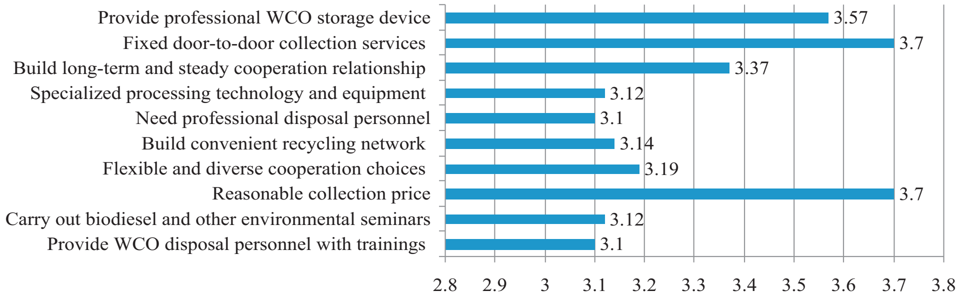


Fig. 6. The respondents' response on the expected cooperation demands on biodiesel manufacturers.

Table 5

Cooperated demands to participate in biodiesel supply chain and factor analysis.

Components	Loadings[a]	%Variance explained	Cronbach's α
Component 1[b] (network and value-added services)		40.1	0.855
Provide WCO disposal personnel with trainings	+0.770		
Carry out biodiesel and other environmental seminars	+0.771		
Reasonable collection price	+0.384		
Flexible and diverse cooperation choices	+0.741		
Build convenient recycling network	+0.860		
Need professional disposal personnel	+0.822		
Specialized processing technology and equipment	+0.786		
Component 2[b] (organizational services)		23.9	0.776
Build long-term and steady cooperation relationship	+0.756		
Fixed door-to-door collection services	+0.843		
Provide professional WCO storage device	+0.816		

[a] After varimax rotation.

[b] Variables with loadings less than 0.5 were omitted.

Table 6

The results of cluster analysis and the characteristics information per cluster.

Attributes	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Motives for waste cooking oil recycling				
Pressure from culture and supply chain	+1.732	−0.605	+1.686	−0.457
Responsibility and competition	+0.689	−0.726	−2.508	+0.062
Policies and health	+0.590	+0.186	−1.369	−0.091
Behavioural atmosphere	−0.147	+2.298	+0.275	−0.260
Awareness about waste cooking oil recycling significances				
Responsibility and capability factor	−14.314	−0.761	−1.008	16.083
Economic and environmental factor	10.562	0.612	−1.407	−9.767
Resource-saving factor	9.373	4.948	0.666	−14.987
Is environmental behaviour helpful to improve the competitiveness? (%)				
Yes	53.5	47.6	40.0	45.9
No	14.0	4.8	10.0	14.0
It is not clear	32.6	47.6	50.0	40.1
Basic information of the samples				
Registered capital (ten thousands RMB)	57.2	34.1	38	46.1
Number of dinners per day	210	196	187	170
Average daily turnover	18,960.47	5000	5880	8631.98
Quantity of edible oils consumed per day	44.88	36.95	41	38.81
Staff number	26	12	14	19
Seat number	113	75	74	93
Disposal ways (%)				
Direct discharge	41.9	61.9	50.0	60.5
Discharge after disposal	46.5	28.6	30.0	30.8
Sell to venders	0.0	0.0	0.0	1.7
Cooperate with professional disposal company	11.6	9.5	20.0	7.0
Disposal frequency (%)				
One time per day	76.7	90.5	100.0	86.6
Special staff (%)				
Yes	55.8	76.2	70.0	72.7
No	39.5	23.8	30.0	25.0
It is considered	4.7	0.0	0.0	2.3
Collecting facilities (%)				
Yes	53.5	57.1	50.0	58.7
No	34.9	42.9	50.0	31.4
It is considered	11.6	0.0	0.0	9.9
Willingness to cooperate with biodiesel (%)				
Willing to cooperate	7.0	4.8	0	3.5
Medium	62.8	76.2	90	72.1
Unwilling to cooperate	30.2	19	10	24.4
Cooperated demands				
Network and value-added services	9.506	−2.039	6.107	−13.574
Organizational services	5.074	6.698	0.373	−12.145
Expected sale price of waste cooking oils				
<500 yuan	60.5	71.4	90.0	63.4
501–800 yuan	27.9	23.8	10.0	32.0
801–1000 yuan	11.6	4.8	0.0	4.7

Table 7
Analysis of WCO recycling logistics system type for biodiesel feedstocks.

Recycling system type	The operator of WCO recycling logistics system	Operational performance of WCO recycling logistics system					Cities or regions of successful practices
		Collection cost uncertainty	Operational ability	Recycling points scope	System flexibility	Financial input requirement	
Public organization type	Government or some commonweal organization	High	Medium	Big	Weak	Very high	Kyoto Shanghai
Producing company type	Biodiesel manufacturer	Very high	Weak	Small	Weak	Very high	Norfolk Yangzhou
Third party type	Special recycling company or logistics company	Low	Strong	Medium	Very strong	Low	Ningde Beijing Germany
Mix type	Combinating cooperation of government and some company	Very low	Very strong	Very big	Strong	High	Brazil

Notice: The 5-point Likert scale was adopted to describe the characteristics of various recycling types based on specialists' consultation.

- Cluster 4 includes 69.9% of the total survey sample. They think that only "responsibilities and competition" plays an important role in WCO recycling. They agree little on the roles of the other three motivational factors.

It can be seen from the description of various features in Tables 6 and 7 that there is a notable difference between Clusters 1 and 4, which also include the most surveyed restaurants (87.4%). In terms of the understanding of WCO recycling, Cluster 1 agrees on "economic and environmental factor" and "energy-saving factor" but not the factor of "responsibility and capability". The pattern of responses in Cluster 4 is opposite to that of Cluster 1. Clusters 2 and 3 hold very similar ideas:

- In terms of whether environmental protection will improve competitiveness, 53.5% of the surveyed restaurant enterprises in Cluster 1 thought that environmental protection is beneficial to the improvement of competitiveness, but only 45.9% of the restaurant enterprises in Cluster 4 held this the opinion.
- In terms of basic corporate information, the average scale of Clusters 1 and 4 is bigger than that of Clusters 2 and 3. The waste oil consumption of Cluster 1 is greatest, reaching an average daily oil consumption of 44.88 kg, and that of Cluster 4 is 38.81 kg.
- In terms of the WCO disposal situation, 41.9% of the restaurant enterprises of Cluster 1 adopted a direct discharge method, making it the lowest of the four clusters in this category. The highest proportion is observed for Cluster 2 (61.9%). In terms of the experience of cooperation with professional WCO recycling companies, the proportion of companies in Cluster 4 is the lowest (7%). In terms of recycling facilities and personnel, Cluster 3 is the worst. In terms of satisfaction with the current method of disposal of WCO, Cluster 1 (88.4%) was higher than Cluster 4 (83.1%).
- In terms of cooperation willingness, Cluster 1 was ranked first. In Cluster 1, 7% of the surveyed restaurant enterprises were willing to cooperate with biodiesel manufacturers, but 30.2% of the surveyed restaurant enterprises were not willing to cooperate with biodiesel manufacturers, which was the highest proportion amongst all four clusters. In terms of the understanding about using WCO to produce biodiesel, the understandings of Clusters 1 and 4 were higher than those of the other categories.
- For the cooperation demand factor, Cluster 1 had very active expectations about "network and value-added services" and "organizational services", but Cluster 4 was completely the opposite, holding passive attitudes. Cluster 2 is basically similar to Cluster 1, and Cluster 3 holds passive attitudes towards "network and value-added services".

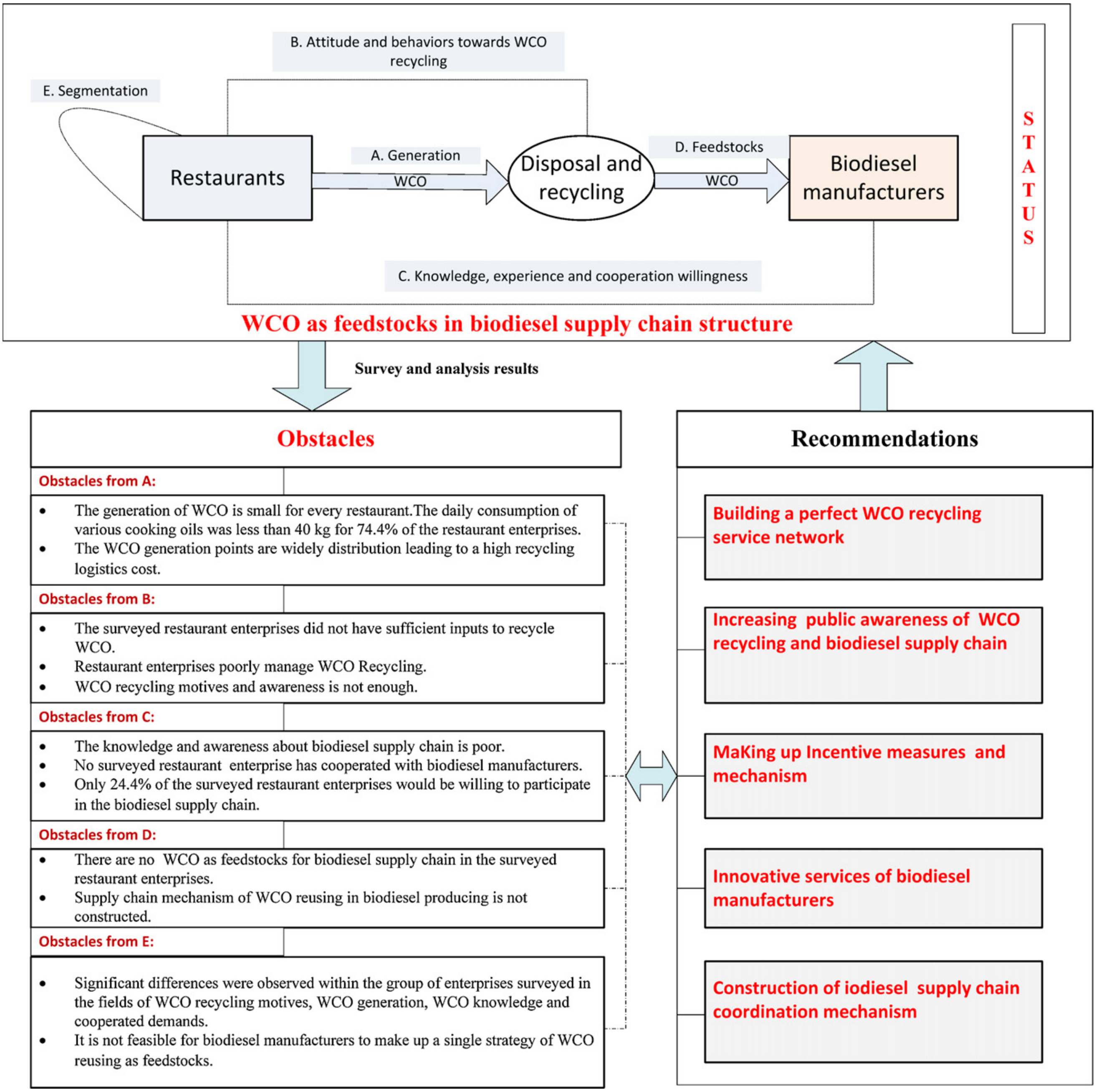
In general, we can conclude that Cluster 1 is concerned about the environment, has active recycling awareness and behaviours, a better understanding of using WCO to produce biodiesel, stronger cooperation willingness, and sensitivity to the stimulation of external factors. We call Cluster 1 the "active group" that participates in the biodiesel supply chain. Compared with Cluster 1, Cluster 4 shows opposite attitudes and understandings in many aspects and is not very active. So we call it the "passive group". The other two categories account for small proportions of the surveyed restaurant enterprises and ranked between the former two categories in many aspects; we call them "middle group".

4. Discussions of recommendations for restaurant enterprises as biodiesel supply chain members in Nanjing

4.1. Building a perfect WCO recycling service network

According to Fig. 7, the scale of generation of WCO by restaurant enterprises is relatively small, and the distribution of the generation is relatively wide. This indicates difficulties for biodiesel manufacturers to recycle WCO, and being widely distributed with little output is also consistent with recycling logistics (Fleischmann et al., 2000). This imposes great impacts on the processing mode and production cost of biodiesel manufacturers. At present, most the surveyed restaurant enterprises mainly adopt the direct discharge method or the method of discharge after treatment, together accounting for 90.2% of all enterprises surveyed. The low recycling rate will directly affect the volume of WCO available for recycling. So it is very necessary for biodiesel manufacturers to build a professional recycling logistics system of WCO. Recycling cost and services are the two key performance indicators in the construction of a recycling network (Fleischmann et al., 2000). Table 7 gives four types of recycling logistics system of WCO for biodiesel feedstocks. They are called "public organization type", "producing company type", "third party type" and "mix type":

- Public organization type is meaning that government or some commonweal organization builds and operates the recycling logistics system of WCO in the scope of cities or some regions.
- Producing company type is meaning that biodiesel producers construct their own WCO recycling logistics according to their feedstocks demands and market strategy. Compared with public organization type, this space scale and operational ability is relatively small.
- Third party type is referring that special recycling company or logistics company builds and operates the recycling logistics of WCO in some cities or regions. Given that special recycling


B. Attitude and behaviors towards WCO recycling
E. Segmentation
Restaurants
A. Generation
WCO
Disposal and recycling
D. Feedstocks
WCO
Biodiesel manufacturers
C. Knowledge, experience and cooperation willingness
STATUS
WCO as feedstocks in biodiesel supply chain structure
Survey and analysis results
Obstacles
Recommendations

Obstacles from A:

- The generation of WCO is small for every restaurant.The daily consumption of various cooking oils was less than 40 kg for 74.4% of the restaurant enterprises.
- The WCO generation points are widely distribution leading to a high recycling logistics cost.

Obstacles from B:

- The surveyed restaurant enterprises did not have sufficient inputs to recycle WCO.
- Restaurant enterprises poorly manage WCO Recycling.
- WCO recycling motives and awareness is not enough.

Obstacles from C:

- The knowledge and awareness about biodiesel supply chain is poor.
- No surveyed restaurant enterprise has cooperated with biodiesel manufacturers.
- Only 24.4% of the surveyed restaurant enterprises would be willing to participate in the biodiesel supply chain.

Obstacles from D:

- There are no WCO as feedstocks for biodiesel supply chain in the surveyed restaurant enterprises.
- Supply chain mechanism of WCO reusing in biodiesel producing is not constructed.

Obstacles from E:

- Significant differences were observed within the group of enterprises surveyed in the fields of WCO recycling motives, WCO generation, WCO knowledge and cooperated demands.
- It is not feasible for biodiesel manufacturers to make up a single strategy of WCO reusing as feedstocks.

Building a perfect WCO recycling service network

Increasing public awareness of WCO recycling and biodiesel supply chain

MaKing up Incentive measures and mechanism

Innovative services of biodiesel manufacturers

Construction of iodiesel supply chain coordination mechanism

Fig. 7. The research relationships amongst status, obstacles and recommendations in this paper.

company or logistics company has a high capability in recycling logistics operation and performance management, the third party type has a low cost uncertainty and financial investment. And this type has a high flexibility of recycling logistics system and strongly market adoption.

- Mix type is meaning that multiple actors such as government, biodiesel producer and recycling company jointly build and operate the recycling logistics system of WCO in some cities or regions. This type has many advantages in the field of cost management, operational ability, and recycling scope.

According to Table 7, we suggested that third party type or mix type may be selected to construct the WCO recycling logistics system in Nanjing city.

4.2. Increasing awareness of WCO recycling and biodiesel supply chain

In our study, we found that the surveyed restaurant enterprises attached little importance to the management of WCO recycling and have no sufficient inputs to recycle WCO. Moreover, the surveyed restaurant enterprises lacked extensive understandings of using WCO to produce biodiesel and the significance of biodiesel. The poor public awareness will directly affect enterprises to participate in the biofuel supply chain (Kirsti and Jon, 2008).

In order to increase the restaurant enterprises' awareness of recycling WCO, the three following aspects are very important. First of all, the government of Nanjing city ought to increase the publicity of the significance of WCO recycling and the value of reprocessing as well as publicise the value of biodiesel. It is

Table 8
Some measures to increase public awareness of WCO recycling for biodiesel.

Executing organization	Executing aims	Some key measures
Government in Nanjing	• To cultivate the WCO recycling market environment.	• To propagandize the knowledge and signification of biodiesel and WCO recycling. • To construct the biodiesel industry by reusing WCO. • To make up the developing plan and laws of WCO management. • To reinforce the control of restaurant enterprise' environment management. • To build the systematic measures to promote the WCO recycling.
Biodiesel manufacturers	• To increase the competition power in the WCO recycling market.	• To introduce the advantages of biodiesel supply chain. • To provide restaurant enterprise some attractive marketing projects.

very effective step to promote biodiesel supply chain construction (Steenberghen and López, 2008). Secondly, restaurant enterprises should be encouraged to increase WCO recycling rate, and enhance recycling management. Therefore, biodiesel manufacturers will actively provide restaurant enterprises with cooperation incentives and build good external communication channels, such as advertising and networks. Table 8 gives some measures to increase public awareness of WCO recycling and biodiesel supply chain in Nanjing.

4.3. Making up incentive measures and mechanism

In general, to encourage restaurant enterprises to participate in the biodiesel supply chain, we should not only focus on the demands of restaurant enterprises but also create a supply coordination mechanism suitable for the existing market environment. Only with positive actions by governments, enterprises and consumers can we positively improve WCO recycling, promote the healthy development of Nanjing's biodiesel supply chain and reduce the problem of the supply of raw materials. There are many measures related to promote restaurant enterprises as biodiesel feedstocks:

- Create a green consumption atmosphere, take advantage of the external environment, including customers, laws, and suppliers, to enhance enterprises' social responsibility and environmental awareness, and promote the transformation of production and competition modes (Wong et al., 1996; Schulte et al., 2004).
- Encourage restaurant enterprises to gradually shift their attention from economic benefits to ecological and environmental benefits. Incorporate WCO recycling into the health assessment, class assessment and honour assessment of restaurant enterprises.
- Focus on improving the law enforcement dynamics of the WCO recycling legal system.
- Consider connecting relevant laws about WCO recycling with relevant laws about new energy (Wiesenthal, 2009; Steenberghen and López, 2008). Especially, incorporate WCO recycling into the tax incentive system.

In Table 4, motives for WCO recycling and factor analysis are discussed. We found that four main factors have great effect on the WCO recycling behaviour of restaurant enterprises. From Table 4, it was found that various groups of the surveyed restaurant enterprise have different response on the four main factors relating to WCO recycling motives. According to the research results, it is feasible to propose some incentive measures described in Table 9.

Table 9
Some incentive measures and various groups' response degree.

Types	Incentive measures	Various groups' effective response degree			
		Cluster 1	Cluster 2	Cluster 3	Cluster 4
Responsibility and competition	To give restaurant enterprise to some taxes and fee deration. To increase the purchase price of WCO by some economic supports from the government. To lead restaurant enterprise to manage WCO according to the principles of ISO14000.	High	Low	Low	Medium high
Green supply chain	To increase the green consumption awareness of customers. To improve the green supply chain operations of restaurant enterprises.	High	Very low	High	Low
Law and policies	To establish the laws and policies of WCO management. To erect the standard of green restaurant enterprise.	High	Medium high	Very low	Low
Behaviour atmosphere	T o give some material and sprit encouragements to good recycling behaviour of restaurant enterprise. T o give some material and sprit encouragements to good recycling behaviour of employee.	Low	High	Medium high	Low

Table 10
Innovative services and preference degree of restaurant enterprise.

Innovative services of biodiesel manufacturers	Preference degree of restaurant enterprise			
	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Network and value-added services	Very high	Low	Low	Very low
Organizational services	Very high	Very high	Low	Very low

4.4. Innovative services of biodiesel manufacturers

Except for the low recycling rate, poor recycling awareness and management, biodiesel manufacturers should face the serious competition with other type company for the WCO resources. Our survey addressed that the recycled WCO were purchased by vender (1.2%), farmer (1.5%), disposal enterprise (4.1%). It is crucial for biodiesel manufactures to improving or creating services in order to share with the WCO resources market.

Related to our survey results, the surveyed restaurant enterprises prefer mostly to the services such as “reasonable collection price” (mean value = 3.70) and “fixed door-to-door collection service” (mean value = 3.70). And we found that different groups of the restaurant enterprise have various preferences for services when they have participated in the biodiesel supply chain. Table 10 gives the different response of various groups on services and demands.

Biodiesel manufacturers should take the active group as their preferred target and the passive group as their second target to attract them to participate in the supply chain. Multidimensional perspectives, such as services, price, innovative cooperation and service contents, should be considered. Additionally, demonstrative enterprises for cooperation should be chosen and the strategy of gradually expanding cooperation with restaurant enterprises adopted. Differentiation strategy is an important principle for biodiesel enterprises to cooperate with restaurant enterprises and is personalised service-oriented.

4.5. Construction of biodiesel supply chain coordination mechanism

In our study, we found that Willingness to cooperate amongst restaurant enterprises is low. The survey shows that only 24.4% of the surveyed restaurant enterprises would be willing to participate in the biodiesel supply chain. Most restaurant enterprises just wait and see as a result of a lack of successful cooperation experience, good cooperation partners, low expected earnings, and so on. Building a win-win supply chain cooperation mechanism and focusing on the role of the contract will effectively promote restaurant enterprises’ participation in biodiesel (Kirsti and Jon, 2008).

Table 11
Various cooperation mechanisms between restaurant and biodiesel manufactures.

Groups of restaurant enterprise	Coordination type	Tactical policies
Cluster 1	Strategic alliance	• To build strategic relationship based on the supply chain structure of “biodiesel manufacturer and restaurant enterprise”. • To keep on the long contract and relationship. • To achieve the “win to win” of the supply chain value.
Cluster 2	Contact mechanism	• To develop some relationship based on the short business contract. • To satisfy the demand of contract.
Cluster 3	Contact mechanism	
Cluster 4	Random mechanism	• Do not develop the supply chain relationship based on business contract instead of the point market. • The deal between restaurant enterprise and biodiesel manufacture is random and not fixed.

It is critical to make a diverse supply cooperation mechanism for biodiesel manufacturers according to the differences of various groups of restaurant enterprises. From our research, Cluster 1 is called “active group”. This group is easy to become the most important partners of the biodiesel manufacturers in Nanjing now. Cluster 4 is the major of the surveyed restaurants (69.9%). It is difficult to become the main WCO feedstocks of biodiesel manufactures now. In future time, this group maybe have some significant changes. Table 11 describes the different feasible cooperation mechanism between restaurant enterprises and biodiesel manufactures in Nanjing.

5. Conclusions

With the objective of promoting restaurant enterprises’ participation in the biodiesel supply chain, a survey was conducted and analysed on the generation of WCO, recycling disposal, recycling understanding and motivations, understanding of biodiesel and the willingness and demands to participate in the biodiesel supply chain of WCO of 246 restaurant enterprises. The paper then specified the difficulties and solutions encountered by existing Nanjing restaurant enterprises that act as biodiesel suppliers. This paper describes the main research findings:

- The average daily consumption of WCO of all of the surveyed restaurant enterprises is 39.98 kg (variance = 28.939), and the wide distribution with little output is a limiting factor of WCO recycling.
- The surveyed restaurant enterprises had poor recycling facilities and management. A total of 91.6% of the surveyed restaurant enterprises had no special recycling or disposal equipment, and only 2.44% assigned special personnel to take charge of the daily management of WCO.
- The surveyed restaurant enterprises mainly employed a direct discharge method to dispose of WCO. No restaurant enterprise cooperated with biodiesel enterprises. The surveyed restaurant enterprises reported disposal cost, low recycling rate and high disposal satisfaction.
- The surveyed restaurant enterprises placed more emphasis on the health, resource and environmental benefits of recycling WCO.
- For the surveyed restaurant enterprises, saving costs, stressing the requirements of health and policies and regulations are most important motivational factors in WCO recycling.
- A total of 99.2% of the surveyed restaurant enterprises were uninformed about the relevant operations of biodiesel manufacturers; only 0.8% of the surveyed restaurant enterprises had some knowledge about biodiesel manufacturers but lacked an understanding of the application significance of biodiesel.
- At the time of the survey, the surveyed restaurant enterprises were not too willing to participate in the biodiesel supply chain, so most of them opted to just wait and see.

- The WCO recycling price of RMB800 and below was acceptable to most of the surveyed restaurant enterprises.
- Price, door-to-door collection service and recycling facilities were the important parameters for restaurant enterprises considering participation in the biodiesel supply chain.
- Based on the motivations for recycling WCO, restaurant enterprises were divided into four categories. Based on the degree of restaurant enterprises' participation in the biodiesel supply chain, restaurant enterprises can be divided into an active group, a passive group and a middle group. Amongst these, the active group is the preferred target for cooperation with biodiesel enterprises.
- To encourage restaurant enterprises to participate in the biodiesel supply chain, we recommend an increase in the publicity of biofuels and the supply chain coordination mechanism, improved policies and legal systems and the innovative service mode of biodiesel manufacturers, a perfect recycling service network, and enhanced business awareness and incentive measures of restaurant enterprises, amongst others.

However, this paper has several limitations considering the WCO recycling and biodiesel supply chain construction. First, this survey only concentrated on the restaurant enterprises, and did not relate to the whole biodiesel supply chain partners such as biodiesel manufacturers, decision makers and logistics operators. Second, the scale of the surveyed samples is not enough large to cover Chinese main cities. So the survey results only reflect the status of the Nanjing city. Third, it is lack of the systematic analysis focusing on WCO recycling cost-revenue, WCO generation forecasting, WCO recycling logistics network design and financial supports from governments. In future works, the authors will continue to survey deeply the biodiesel supply chain by increasing the samples numbers in other cities. Another hand, some systematic analysis will be done to describe quantitatively the restaurant enterprises supply chain behaviour when they provide WCO for biodiesel manufactures as feedstocks. Furthermore, we will discuss the supply chain contracts between the biodiesel manufacturers and restaurant enterprise.

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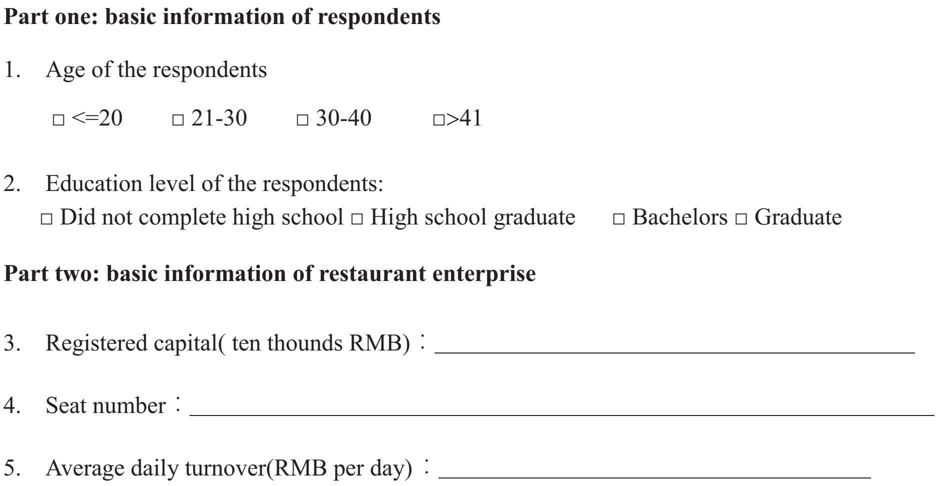
Appendix A. Survey questionnaire used in this study



Part one: basic information of respondents

1. Age of the respondents

☐ <=20 ☐ 21-30 ☐ 30-40 ☐>41

2. Education level of the respondents:

☐ Did not complete high school ☐ High school graduate ☐ Bachelors ☐ Graduate

Part two: basic information of restaurant enterprise

3. Registered capital(ten thounds RMB)：______________________________

4. Seat number：____

5. Average daily turnover(RMB per day)：__________________________

6. Number of dinners per day：____

7. Quantity of edible oils consumed per day (kg)：________________________________

8. Quantity of WCO recycling per day (kg)：________________________________

Part three: management status of WCO

9. Does your enterprise have special management staff for WCO?
☐ Yes ☐ No ☐ No, but it is considered now.

10. Does your enterprise have special recycling facilities for WCO?
11. ☐ Yes ☐ No ☐ No, but it is considered.

12. How about does your enterprise do disposal frequency of WCO?
☐ One time per day ☐One time every 2-3 days ☐ One time every 4-5 days

13. Which way do your enterprise disposal WCO?
☐ Direct discharge ☐ Discharge after disposal ☐ Sell to venders ☐ Sell to farm as feedstuff

☐ Cooperate with professional disposal company ☐ Cooperate with biodiesel enterprises

14. What is your enterprise's satisfaction level of WCO management?
☐ Satisfied ☐ Medium satisfied ☐Unsatisfied

15. What are the selection factors for WCO disposal ways ?
☐ Environmental benefits ☐Economic benefits ☐Disposal costs ☐Aptitudes and capability of the cooperated enterprises ☐Other reasons

Part four: awareness on WCO recycling

16. Can you evaluate your enterprise's viewpoints of the significance of WCO recycling described in Table A-1?

Table A-1 The significances of WCO recycling

Aspects	**Greatly disagree**	**Disagree**	**Medium**	**Agree**	**Greatly agree**
WCO is recyclable, saving resources.					
Can reduce the emissions of carbon dioxide.					
WCO is usually wasted.					

WCO recycling can reduce the production cost of enterprises.
WCO recycling can improve urban environment.
WCO recycling can effectively improve the health conditions of enterprises.
WCO recycling can effectively improve the competitiveness of enterprises.
WCO recycling can effectively reduce the disposal cost of urban environment.
WCO is the social responsibility of enterprise.

17. Can you evaluate your enterprise’s motives of the WCO recycling described in Table A-2?

Table A-2 Motives of the WCO recycling

Motive factors	**Very important**	**Important**	**Medium**	**Unimportant**	**Very unimportant**
Fixed management behavior					
To save the cost					
To achieve corporate social responsibility					
For the sake of enterprise competition					
Private acts of employees					
For the sake of health					

Policy and regulatory requirements
Pressure from customers
Manifestation of corporate culture
Guide of waste disposal company

18. Do you have any knowledge about the biofuel supply chain?
☐Yes, I have some knowledge. ☐ I have no knowledge.

19. Do you know that WCO will be used to produce biodiesel?
☐Yes ☐ No ☐ I don't know.

20. What is your opinion about the applications of biodiesel described in Table A-3?

Table A-3 Opinion about the applications of biodiesel

Viewpoints	**Agree**	**Disagree**	**Uncertainty**
Reduce emissions and protect environment			
Relieve energy crisis			
Strengthen China's energy security			
Increase company revenue			
Exiting technology is immature			
The price is higher than that of fossil fuel			
Cause the food price to rise			
Have side effects on the engine			
Engine can be used after being modified			

21. Can you evaluate your enterprise's willingness to cooperate with biodiesel manufacturers?
☐ Willing ☐ In a general sense ☐ Unwilling

22. If your enterprise has cooperated with biodiesel manufacturers, what is the expected sale price of WCOs?

☐ ≤500 yuan per ton ☐ 500-800 yuan per ton ☐ 800-1000 yuan per ton ☐ ≥1000 yuan per ton

23. If your enterprise has participated in biodiesel supply chain, which services do your enterprise like to achieve?

Table A-4 Cooperated demands in biodiesel supply chain

Cooperated demands	**Very necessary**	**Necessary**	**medium**	**Unnecessary**	**Very unnecessary**
Build long-term and steady cooperation relationship					
Fixed door-to-door collection services					
Provide professional WCO storage device					
Provide WCO disposal personnel with trainings					
Carry out biodiesel and other environmental seminars					
Reasonable collection price					
Flexible and diverse cooperation choices					
Build convenient recycling network					
Need professional disposal personnel					
Specialized processing technology and equipment					

24. Do you think that your enterprise's environment management will increase market competition capability?

☐ Yes ☐ No ☐ Unsure

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